Farmland foods: Black-necked Stork *Ephippiorhynchus asiaticus* prey items in an agricultural landscape

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Introduction

Black-necked Stork *Ephippiorhynchus asiaticus* is a resident stork species in India, with the largest breeding population found in unprotected agricultural landscapes (Sundar 2003). It is the rarest resident large waterbird in the Gangetic floodplains (Sundar 2004, 2005, 2006), and is suspected to be declining due to habitat deterioration (Elliott 1992, Hancock *et al.* 1992).

Black-necked Storks are entirely carnivorous (Elliott 1992, Hancock *et al.* 1992) and require nearly 1 kg of food each day (Maheswaran & Rahmani 2002). Studies in protected, managed wetlands in India and Australia showed that Black-necked Storks were piscivorous (Dorfman *et al.* 2001, Maheswaran & Rahmani 2002). Other observations, however, reveal that Black-necked Storks are capable of taking a much wider range of prey. These include birds, such as Little Grebe *Tachybaptus ruficollis* (Sundar & Kaur 2001), Australasian Grebe *T. novaehollandiae* (Clancy 2008), Indian Pond Heron *Ardeola grayii* (Breeden & Breeden 1982), Common Coot *Fulica atra* (Breeden & Breeden 1982, Verma 2003, Ishtiaq *et al.* 2004), Northern Shoveler *Anas clypeata* and Pheasant-tailed Jacana *Hydrophasianus chirurgus* (Ishtiaq *et al.* 2004), sea turtle hatchlings (Whiting & Guinea 1999), Eastern Long-necked Tortoise *Chelodina longicollis* (Clancy 2008), eggs of riverine turtles (Chauhan & Andrews 2006), crabs, molluscs, insects and other arthropods, and various species of lizard and snake (Elliott 1992, Hancock *et al.* 1992, Dorfman *et al.* 2001, Ishtiaq *et al.* 2004, Clancy 2008). Stomach content analyses of nine storks in Australian wetlands also confirmed their breadth of diet, with the storks having consumed a variety of insects (grasshoppers and beetles), amphibians, reptiles and birds, as well as plastic, cattle dung, plant material and pebbles (Clancy 2008).

Outside protected and managed wetlands, Black-necked Storks in western Uttar Pradesh in north-central India use a variety of habitats, including crop fields, fallow fields and irrigation canals (Sundar 2005). Their diet in such conditions is undocumented but is important to understand, given imminent intensification of cultivation and the species's apparent population decline. In this paper, I provide a list of prey items Black-necked Storks were observed eating in different habitats and seasons in an extensively cultivated landscape of the Gangetic floodplains. This paper adds to the very sparse literature on this rare and seldom-studied waterbird, and is the first documentation of its prey items outside protected wetland areas.

Study area and methods

The observations were made in the area bordering Etawah and Mainpuri districts, Uttar Pradesh, north-central India. Agriculture is the main occupation in these districts, and the landscape is a mosaic of human habitation, crop fields, wetlands (lakes, ponds, shallow marshes and reed beds), linear marshes along roads (formed by rain-filled ditches dug during road construction), alkaline wastelands and irrigation canals. Three seasons were identified, based on temperature and rainfall regimes. Monsoon (July–October) was the primary rainfall season, with flooded rice paddies being the dominant crop in the landscape. The relatively drier winter (November–February) had wheat and mustard as the primary crops. Fields were kept wet but not flooded during this season. During the hot dry summer (March–June) fields were fallow and very few were planted with fruits and vegetables. In mid- and late June, fields were flooded in anticipation of the monsoon prior to the planting of paddy rice.

I carried out *ad hoc* observations of prey items consumed by Black-necked Storks. Twenty-nine territorial breeding pairs were identified, based on location and number of chicks (details in Sundar 2003). Observations were carried out between 1998 and 2010 while traversing road routes that covered territories of all the identified pairs. Territories were scanned each year to determine breeding success of pairs, and feeding observations were made during these surveys. After being located, storks were observed only for a few minutes, and the observations presented in this paper were completed in less than 50 hours. Fieldwork was intensive during 1999–2002, with constant seasonal coverage, and c.70% of the data are from this period. Visits were less intensive during 2003–2010 and seasonal coverage during these infrequent visits was also similar. The total number of stork observations was c.1,000, and prey-catches were recorded during about 10% of the observations. For this paper, habitats are categorised into crop fields (comprising rice, wheat and fallow fields), wetlands (comprising perennial lakes and seasonal marshes), roadside ditches, and irrigation canals. Black-necked Storks preferentially used wetlands in all seasons and flooded rice paddies in the monsoon (Sundar 2005). Irrigation canals were always used in proportion to their availability in all seasons, and non-rice-crop fields were used to different extents across seasons (Sundar 2005). Although plumage characteristics can be used to distinguish Black-necked Storks of different ages (Sundar *et al.* 2006), 85% of prey-catch observations were of adult birds; thus the data are not segregated by age. Prey-catch observations of younger birds were only from winter and summer but included all habitat categories. Prey items were identified to broad taxonomic group only, and no statistical analyses were used since the data were not collected systematically.

Results

A total of 105 prey-catches were observed, of which the prey could be identified in 77 instances (73%). Prey-catches were seen equally in all three seasons (Table 1). Observations of prey-catches were mostly from crop fields, roadside ditches, wetlands and canals, in that order (Table 2). The largest numbers of unidentified items were from crop fields because of the smaller size of prey items. Fish and frogs were the most frequently taken prey items, the former mostly from wetlands and the latter mostly from roadside ditches. Small fish and frogs were swallowed immediately on capture, while larger ones were shaken violently and placed on the ground and beaten with the bill before being swallowed whole. Both juvenile and adult storks were seen capturing frogs. Molluscs were the next most frequent prey item, taken mostly from canals, and only by juvenile birds (n = 11, Table 2). Crabs and insects were taken infrequently, and mostly from crop fields. Two of the three insects were

Table 1. Prey items of Black-necked Storks (broad taxonomic units, in alphabetic order) taken in different seasons observed at Etawah and Mainpuri districts, Uttar Pradesh, India between 1998 and 2010.

Prey	Summer	Monsoon	Winter	Total items
Bird	0	0	1	1
Crab	0	4	1	5
Fish	6	6	12	24
Frog	13	5	9	27
Insect	3	0	3	6
Lizard	1	0	0	1
Mollusc	5	0	6	11
Snake	0	1	1	2
Unidentified	8	11	9	28
Total	36	27	42	105

Table 2. Prey items of Black-necked Storks (broad taxonomic units, in alphabetic order) taken in different habitats observed at Etawah and Mainpuri districts, Uttar Pradesh, India between 1998 and 2010.

Prey	Canal	Fallow field	Rice	Wheat	Roadside ditch	Wetland	Total items
Bird	0	0	0	0	0	1	1
Crab	0	0	3	1	1	0	5
Fish	1	0	0	0	3	20	24
Frog	2	0	1	1	19	4	27
Insect	0	3	0	3	0	0	6
Lizard	0	1	0	0	0	0	1
Mollusc	10	0	0	1	0	0	11
Snake	0	0	0	1	1	0	2
Unidentified	1	6	9	7	2	3	28
Total	14	10	13	14	26	28	105

orthopterans (grasshoppers), and one was a beetle taken from drying cow-dung in a fallow field. Many of the unidentified prey were probably arthropods. Snakes were observed being taken twice: once each from a wetland and a roadside ditch. Both appeared to be Chequered Keelback *Xenochrophis piscator*, a very common water snake in the region. Snakes were caught in shallow water and killed by violent shaking and pecks. One snake tore into two pieces during the process, while the other was swallowed whole. One bird, a Little Grebe, was taken in a wetland (shallow marsh): it was shaken violently and beaten with the bill several times before being swallowed whole. One lizard, probably the common and widespread Changeable Lizard *Calotes versicolor*, was taken from a fallow field that bordered scrub with low *Prosopis juliflora* vegetation.

Discussion

Despite its unsystematic nature, this is the first dataset on the diet of Black-necked Stork in an unprotected, cultivated area. In this landscape, wetlands are not managed for waterbirds but nevertheless sustained impressive populations of several large waterbird species, including Sarus Crane *Grus antigone*, Painted Stork *Mycteria leucocephala*, Asian Openbill *Anastomus oscitans* and Woolly-necked Stork *Ciconia episcopus* (Sundar 2003, 2004, 2009). Concomitant with the diversity of habitats, Black-necked Stork prey items in Etawah and Mainpuri were far more diverse than those observed in managed wetlands in northern Uttar Pradesh (Maheshwaran & Rahmani 2002) and Australia (Dorfman *et al.* 2001) but were similar to those taken in other managed wetlands where the species exhibits generalist feeding (Elliott 1992, Hancock *et al.* 1992, Ishtiaq *et al.* 2004). None of the prey items at the broad taxonomic level is new to the known diet of Black-necked Stork. No small mammals or turtles were seen being taken, though they are known to feature in the species's diet (Elliott 1992, Hancock *et al.* 1992, Clancy 2008).

Crop fields dominated the landscape, and most prey-catches observed were from this habitat. The relatively wet nature of the primary crops in this area in two of the three seasons is clearly conducive to Black-necked Stork persistence. Wetlands and roadside ditches (which closely resemble wetlands) provided good prey resources, matching habitat use observations in the same area (Sundar 2004). Prey sizes were much larger in these habitats, also suggestive of a higher quality of resources available in wetlands despite a larger number of prey-catches in crop fields. As evidenced by number of observations, they also appear to be the most important feeding habitats for Black-necked Stork. Since roads were used for surveys, the apparent importance of roadside ditches may be exaggerated. However, some of the roads also ran alongside canals, where feeding bouts were relatively rare, suggesting that the observations help provide general indications of important foraging habitats for the species. Past information has suggested that the species requires undisturbed, large wetlands (Luthin 1987, Elliott 1992, Hancock *et al.* 1992), and such prominent use of crop fields and roadside ditches, as well as irrigation canals by juvenile Black-necked Storks for feeding, was unknown.

Farmers in the study area are generally tolerant of waterbirds, even those that damage fields by nest construction (Sundar 2009). After habitat destruction, human disturbance and capture for zoos are suspected to be the biggest threats to Black-necked Storks (Elliot 1992, Hancock *et al.* 1992). Favourable attitudes of farmers may, therefore, be an important aspect responsible for the persistence of Black-necked Storks. The geographical extent to which such favourable attitudes exist is not understood. A thorough study of prey availability, the dietary habits of Black-necked Storks and farmer attitudes toward the storks in the various habitats in this agricultural area will greatly help understand how this large, declining and relatively rare species can be retained in agricultural landscapes. In addition, understanding threats to important foraging habitats to attempt to reduce wetland attrition is critical to the species in this landscape.

Despite the area having a high human population density (>800 people/km^2; Office of the Registrar General of India 2011) and a high degree of cultivation, the landscape appears to retain prey diversity and density at levels adequate for a large species such as Black-necked Stork to maintain a healthy, breeding population (see Sundar 2003). In the study area, unmechanised cultivation techniques, cultural practices of maintaining community wetland patches, absence of targeted persecution, availability of nesting trees, and the lowest intensity of cropping (percentage area under cultivation) in Uttar Pradesh (pers. obs.) may be combining to provide conditions conducive for waterbird persistence. This situation appears to be unique for large storks anywhere (Elliott 1992, Hancock *et al.* 1992, Benn *et al.* 1995).

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Taxonomic notes on some Asian babblers (Timaliidae)

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A reconsideration of the taxonomy of Asian babblers (Timaliidae) (Collar 2006) indicated that much work remains to be done. Here I briefly pursue various issues, for which I examined specimens of birds in the American Museum of Natural History, New York (AMNH), Natural History Museum, Tring, UK (BMNH), Muséum National d'Histoire Naturelle, Paris (MNHN), Philippine National Museum, Manila (PNM), National Museum of Natural History, Washington DC (USNM), and Western Foundation of Vertebrate Zoology, Caramillo, California (WFVZ), following a system for assessing species limits outlined in Collar (2006), modified and advanced by Tobias *et al.* (2010). Differences between taxa in morphological characters are graded such that an exceptional one scores 4, major 3, medium 2, minor 1, and scores are allowed for a maximum of three morphological characters (others are mentioned, with the letters 'u' for 'unscored', but with the putative score I judge appropriate in square brackets), two vocal characters, two biometric characters (assessed for effect size using Cohen's *d* where >0.2 triggers minor, >2 medium, >5 major and >10 exceptional) and one behavioural or ecological character. A total score reaching or exceeding the threshold of 7 qualifies the taxon for species status (further details in Tobias *et al.* 2010). An online calculator (http://www.uccs.edu/~faculty/lbecker/) was used to determine Cohen's *d* effect sizes. Measurements (bill tip to skull, wing curved) were taken in millimetres, and differences between taxa were compared using two-tailed t-tests.

Rhinocichla (mitrata) treacheri as a species

Judgement on the validity of this split came too late for inclusion in Collar (2006), and it was made without supporting justification in Collar & Robson (2007).

The form *treacheri* (Borneo) differs from nominate *mitrata* (Peninsular Malaysia and Sumatra) in its orbital ring being yellow and incomplete, not white and complete (3), ear-covert and nape chestnut, not grey (2), upper submoustachial and interramal area chestnut, not black, and greater extent of chestnut on chin (2), underparts ochreish and with shaft-streaks (u [1]), narial feathering, lores and superciliary area paler chestnut (u [1]), and forecrown-blaze greyer (u [1]), total 7. Mensural differences are very slight (10 of each taxa examined). Photographs in Pilgrim *et al.* (2009: 30) show the most salient of these characters well.

Liocichla (phoenicea) ripponi as a species

Again, judgement of the specific status of *L. ripponi* came too late for presentation in Collar (2006), and the split in Collar & Robson (2007) was without justification.

The form *ripponi* (with *wellsi*) differs from nominate *phoenicea* (with *bakeri*) in having the crimson of the face and black lateral crown-stripe replaced by much brighter scarlet extending clearly over the eye, onto the lores and over the malar area onto the chin (3), crown grey (2), upperparts greyer (u [1]), underparts markedly paler and buffy-greyer (2), undertail buffy-grey with an orange wash (where *phoenicea* is bronzy-red) (u [1]), and a longer tail (*phoenicea/bakeri* mean 100.3 ± 3.31, n = 10 *phoenicea*, 10 *bakeri*; *ripponi/wellsi* 107.3 ± 3.58, n = 10 *ripponi*, 11 *wellsi*; effect size = 2.05) (2), total score 9. (While all *phoenicea* material was unsexed and most *wellsi*, which is rare in collections, were male, the sample for *bakeri* and *ripponi* consisted of five males and five females, and while females averaged smaller than males the differences were too slight to suggest that sexual bias in the other taxa could have affected mensural comparisons.)

Delacour (1933: 88) reported that specimens in BMNH indicate that the forms *ripponi* and *bakeri* intergrade in the 'Kauri-Kachin tract' in Upper Burma. I have checked the Myanmar material held in BMNH and can find only a single skin, 1905.8.16.156 (taken by G. Rippon in the said tract; undated),„which might be interpreted as an intergrade, owing to its rather poorly differentiated crown and underparts: indeed its facial and undertail colours and patterns are as in *ripponi* (whether the red meets on the throat cannot be judged as this area is abraded to the skin) while its measurements are those of *bakeri* (tail 99 mm). It is difficult to know what to make of this specimen, which is in very poor condition, but a zone of hybridisation or intergradation is allowed for by Tobias *et al.* (2010); species status for *ripponi* is not invalidated.